In the evening there was a concert in the garden of the Exhibition in honour of the members of the Congress.

During Monday, Tuesday, and Wednesday the two sections of the Congress—the Botanical and Horticultural—met in the Botanic Garden in the upper and lower halls of the Botanical Institute. The different subjects contained in the programme were duly discussed, and a resolution of Congress on the different points raised terminated each discussion. The method adopted at these meetings was one which might well be followed in other assemblies, and is one which reflects great credit on the President of the Organisation Committee, M. Charles de Bosschere. All the subjects to be discussed were treated of in longer or shorter papers, all of which were printed in the four fasciculi of the *Preliminary Reports* issued to the adherents of the Congress. In this way all the members had the subjects before them in a tangible form, and discussion was easy. Might not the British Association take a hint from this? Without giving up the method at present followed, let the British Association add to their work a discussion on one or two subjects of importance, papers by special men to be printed beforehand, so as to be in the possession of those who can discuss the subject at the meeting.

The subjects of discussion—twenty-two in number—were mostly of considerable botanical interest, others being purely horticultural, the question of the Congo being general. Perhaps the most important subjects were the discussions on botanical laboratories, on the amount of instruction in cryptogams to be given in different parts of the botanical course of study and the recent progress of botany in different countries. It is important to notice that the general opinion of the Congress was in favour of two kinds of botanical laboratories, those of instruction and those of research, and there can be no doubt that in every society research should be encouraged in every way and be the highest object of their organisation.

On the evening of August 3 the Burgomaster of Antwerp held a reception at the Hôtel de Ville, which was very largely attended by the members. On the evening of August 4 Dr. Henri Van Heurck, the Director of the Botanic Garden, gave a most interesting series of microscopical demonstrations in the meeting-room of the Botanical Section. The application of the electric light to microscopic work was shown, and nothing could exceed the perfection of the arrangement employed by Dr. Van Heurck. *Surirella gemma*, *Amphipleura pellucida*, and Noberts's 19th band were shown in a manner which left nothing to be desired; and in the case of Amphipleura, not only were the striæ shown as distinctly as one is accustomed to see them in *Navicula rhomboides*, but, by illumination through the object-glass, the striæ were distinctly resolved into beads; by oil-immersion lenses, of which, as of other object-glasses by all the best makers, Dr. Van Heurck possesses a remarkable series. The electric light employed is obtained by a bichromate battery (Trouvé's) and Dr. Helot's photophore. As the photophore works equally well with an accumulator, and where there is no difficulty in getting the accumulators charged, no better illumination can be got, and this I would strongly recommend to all microscopists. Altogether Dr. Van Heurck's demonstration will be remembered as one of the most interesting things connected with the Congress. On the evening of Wednesday there was a grand banquet, when the members spent a very pleasant evening together.

On Thursday morning the Congress left by train for Brussels. On arrival, the members went to the Natural History Museum, and were shown through the building by the Director, who kindly admitted the members of the Congress at an early hour. Next, the party proceeded to the Botanic Garden, where they were received by Prof. Crepin and others. The herbarium, museum, garden, and hot-houses were all inspected, and then the Members of the Congress were entertained in the orangery of the garden to a luncheon given by the Members of the Royal Botanic Society of Belgium. After luncheon the party proceeded by tramway to Laeken, to visit the Winter Garden, which had been opened to them by his Majesty the King of the Belgiums. Mr. Knight, the Inspector of the Royal Gardens, accompanied the party, and pointed out the objects of interest. Friday was to be devoted to an excursion to Ghent, and Saturday to a botanic excursion in the neighbourhood of Herrenthals, Dolen, and Gheel, where the Members of the Congress were to disperse. I left the party at Brussels, spending Friday at Liége with Prof. Morren, who showed me the splendid new laboratory in the pretty little garden under his charge. I afterwards visited Prof. Suringar at Leyden, and saw some of the treasures he has just brought back with him from the Dutch West Indian Islands, where he has been able to make extensive botanic collections of living and dried specimens.

W. R. McNab

August 31

THE FAUNA OF THE SEA-SHORE[1]

THE marine fauna of the globe may conveniently, in the pursuit of certain lines of scientific study, be divided into three groups according to the regions inhabited by it. There is the littoral fauna comprising the animals inhabiting the sea-shore and the shallow waters in its immediate neighbourhood, the deep-sea fauna, and the pelagic fauna, the latter occupying the surface waters of the ocean. Each of these regions presents certain marked peculiarities of conditions of existence, and exhibits, in accordance with these, certain special characteristics in the composition and history of the origin of its fauna. The deep-sea is devoid of sunlight and therefore of plant life. It is dark, cold, and monotonous, being devoid of day and night and periodical or irregular changes of any kind. Its habitation probably dates from no very great antiquity. The ocean surface can support only a peculiar fauna of animals adapted for floating or constant swimming, and affords no shelters nor resting-places.

As Prof. Lovèn writes[2]: "The littoral region comprises the favoured zones of the sea, where light and shade, a genial temperature, currents changeable in power and direction, a rich vegetation spread over extensive areas, abundance of food, of prey to allure, of enemies to withstand or evade, represent an infinitude of agents competent to call into play the tendencies to vary which are embodied in each species and always ready, by modifying its parts, to respond to the influences of external conditions." It is in this littoral zone where the water is more than elsewhere favourable for respiration because of its aëration by the surf and where constant variation of conditions is produced by the alternation of the tides that the ancestors of all the main groups of the animal kingdom came into existence, and all the primary branches of the animal family tree first commenced to grow. It is here, probably, that the first attached and branching plants were developed, thus establishing a supply of food, and rendering possible the colonisation of the region by animals.

The animals inhabiting the littoral region are adapted in most various ways to withstand and endure the special physical conditions which they there encounter—the action of the surf, the retreat of the tides, the numerous enemies. Either they burrow deep in the sand, or cling tight to, or even bore into, the rocks, or develop hard shells or skeletons, or protect themselves by other modifications. Probably all hard shells and skeletons of marine invertebrata have thus originated in the littoral

[1] A Friday evening lecture at the Royal Institution, delivered January 23, 1885, by Prof. H. N. Moseley, F.R.S.

[2] "On Pourtalesia, a genus of Echinoidia." by Sven Lovèn. (Stockholm, 1883, p. 86.)

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zone for purposes such as these. It is found that these hard structures tend to degenerate and disappear both in the pelagic and deep-sea regions.

It is a most remarkable fact that almost all these shore animals in their early development from the egg pass through free-swimming larval stages which are closely alike in form for very widely different zoological groups. As a familiar example may be taken the case of the common oyster. The egg of the oyster develops into a peculiar free-swimming larva known as a Trochosphere. It is globular in form and divided by a transverse band of cilia into a smaller anterior and larger posterior area. The mouth opens just behind the ciliated band. The larva swims actively by means of its cilia. After a time it develops a pair of shells, and becomes metamorphosed into an oyster, and attaches itself immovably by one of its shells to the sea-bottom. Its shells increase in size and thickness, and form a protection against its enemies. This same trochosphere larva is common to a very large number of Mollusca of all varieties and shapes in the adult condition, and an essentially similar trochosphere is common to a large number of annelids. It is most remarkable that there should be so close a resemblance between the larva of two adult forms so widely different in all respects as an oyster and a worm. An old explanation of such facts was that such actively-moving larvæ were contrivances for procuring the wide diffusion of sedentary or less active adult forms, which might thus be conceived as of later origin than the forms themselves. But if this were the case, it is inconceivable that having arisen from so widely different starting points, the larvæ should have attained so closely similar a structure. The only real explanation of the matter is that the common larval form represents a common ancestor, from which the various adult forms, in the existence of which it is now only a phase, diverged. There was thus a common freely-swimming ancestor of the annelids and mollusca, and it seems probable that the entire littoral fauna must have been derived originally in remote antiquity from small primitive and simply organised free-swimming ancestors. All evidence seems further to point to the conclusion that the primitive ancestors of all plants were also free-swimming. The free-swimming ancestral representatives of life no doubt partly inhabited the open sea, leading a pelagic existence, partly swarmed in sheltered bays and pools on the coasts, as the larvæ of the littoral animals do now. The free-swimming plants gradually produced attached descendants, which colonised the shores, and the animals, finding there a supply of food, gradually adapted themselves to the more complicated conditions of shore life. The late Prof. Balfour, in his far-famed work on "Embryology," in discussing the character of larvæ of the kind under consideration, spoke of them as possibly reproducing the characters of some ancestral forms "which may have existed when all marine animals were free swimming."[1]

A peculiar instance in which there can be but little doubt, is that of the common barnacles. These in the adult condition are firmly fixed to supports of various kinds, and withstand the most violent action of the surf. The common acorn barnacles cover the most exposed bare rocks of our coasts, where the waves are heaviest, and nothing else can live. They have developed the stoutest of shells to protect themselves. In the young larval condition, however, they are actively free-swimming larvæ of typical crustacean structure, evidently adapted for pelagic existence, and to be found in swarms at the sea-surface, actively engaged in it. They attach themselves, and become immovably adherent and sedentary, and invested by a shell. There can be no doubt in this case that the locomotive larva represents the ancestral form, for allied crustacea still exist in abundance as adults.

[1] F. M. Balfour, "Comparative Embryology," vol. ii. p. 305.

A most important instance is that of the Echinoderms, the adults of the various groups of which, the sea-urchins starfish, brittle stars, holothurians, and crinoids are most, widely different in form, and adapted in most various ways to shore life. Yet these all pass through free swimming larval stages which are most remarkably alike. Supposing the adult forms to have been antecedent, it is quite impossible that a series of larvæ could have been developed independently from starfish, echini, holothurians, and brittle stars, and have attained this remarkable coincidence of structure. This common larval form must represent the ancestral condition, the free-swimming pelagic ancestor from which the echinoderms have sprung.

The fixed and inert sponges are developed from free-swimming ciliated larvæ, and Prof. W. J. Sollas[1] has observed that the young larvæ of the sponge *Oscarella lobularis* are retained longer within the parent in the case of specimens occurring on the coast of Brittany than in that of specimens found in the Mediterranean. He attributes this difference to the influence of the quieter sea and absence of tides in the latter case. The larvæ have come to be longer retained where the risk of their loss by current and tide is greater. By the gradual action of similar influences, no doubt, the loss of larval stages in so many instances has come about. It is probable that there is a special tendency to such loss in the case of deep-sea animals. Hoek[2] has recorded the loss of the nauplius stage as a free-swimming one in the case of a deep-sea scapellum from a depth of 506 fathoms. One of the best examples of the special adaptation by modification of animals sprung from pelagic ancestors for littoral existence is that of the Madreporarian corals, the far-famed builders of reefs. Each coral colony is sprung from a locomotive planula larva, swimming by means of cilia. The larva attaches itself, and developes into a polyp, and acquires a hard skeleton, and by budding produces a large colonial stock. The massive stocks thus formed and strengthened form reefs which are barriers to the waves. They flourish in the water churned by themselves into surf, and thus specially aërated and fitted for their respiration, and between their branches and interstices they sift out the fine pelagic animals on which they feed from the surface water. Probably the advantages thus gained is the cause of their assumption of the colonial form and development of their stout and massive skeletons. Possibly this is the reason why scarcely any colonial Madreporaria occur in deep water, although other colonial animals are abundant in the depths.

The origin of the vertebrata is a complex question, but they are probably sprung from a very simple free-swimming ancestor, as is shown by the survival of a simple ciliated gastrula as an early stage in the developmental history of Amphioxus. An exactly similar developmental stage precedes the trochosphere form in the oyster, and the characteristic larvæ in the case of the echinoderms, and occurs as an early stage in a wide range of other forms. From this ciliated gastrula develops Amphioxus, one of the most interesting components of the fauna of the coasts, one of the most primitive of vertebrates now existing. The Ascidians, which are in the adult condition as inhabitants of the coasts, mere inert sacs, extreme instances of degeneration, are derived from free-swimming larvæ of pelagic habits which show distinct vertebrate structure and have myelonic eyes, which, as Prof. Lankester has pointed out, could only have originated in an animal of pelagic habits. The Ascidians, before reaching their vertebrate larva stage, pass through a gastrula stage like Amphioxus. It is possible, therefore, that their ancestors have twice taken from pelagic to littoral existence, having relinquished the shore for a period after their first experience of it, and returned to it again; whilst some of their close allies, such

[1] W. J. Sollas, *Quart. Journ. Micro. Sci.*, 1884, p. 612.
[2] Report on the Cirripedia. *Challenger* Report, Zoology, vol. viii. p. 75.

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as Appendicularia, have never resought the shore, and consequently have never degenerated to qualify for littoral life. The peculiar breathing apparatus adopted by the vertebrata occurs nowhere else in the animal kingdom except in the extraordinary worm-like Balanoglossus. The apparatus, as is well known, consists of a series of slits, opening from the exterior at the sides of the fore part of the body directly into the throat, the anterior part of the digestive tract. The water to be respired is taken in at the mouth and ejected through the gill slits. The late researches of Mr. W. Bateson, of Cambridge, have shown that Balanoglossus, besides breathing by gill slits, shows many other remarkable affinities, both in structure and development, with the vertebrata. Now, Balanoglossus, a shore-inhabiting form which lives buried in the sand, is developed from a most remarkable larva known as Tornaria, which is intermediate in form between a Trochosphere and a star-fish larva. It is quite possible that this extraordinary larva Tornaria may point to the former existence of a primitive pelagic ancestor common to the Annelids, Echinodermata and Vertebrata. Possibly the use of gill slits as a respiratory apparatus first arose in a shore-inhabiting ancestral form, such as Balanoglossus, and hence their presence at the anterior extremity of the body, that nearest to the surface when the animal is concealed in the sand.

It appears not impossible that Amphioxus may once have possessed a larval stage somewhat resembling Tornaria, following on its gastrula stage, and has lost it just as one species of Balanoglossus has lost the Tornaria stage. The developmental history of only one species of Amphioxus is as yet known, and investigation of that of other species may yet reveal something of the kind suggested.

The littoral zone not only became itself stocked with an immense variety of specially adapted inhabitants, but has given off colonists to the three other faunal regions. The entire terrestrial fauna has sprung from colonists contributed by the littoral zone. Every terrestrial vertebrate, every frog, reptile, bird, and mammal, bears in its early stages of development the gill slits still perforating its throat as in its aquatic ancestor. The tadpole still uses them when young for breathing, though they close up completely in the adult frog and in all the higher vertebrates before birth. In some of the tailed Amphibia, like the Axolotl, the breathing is by external gills and also by lungs which are modifications of the air-bladder of fish. In these the gill slits remain open, although they have no longer any respiratory function. It is amusing to watch tame Axolotls when fed in aquariums with large worms. They snap the prey down hurriedly and close their mouths, but usually in a moment or two their throat begins to twitch uncomfortably as if intensely tickled, and one end of the worm appears out of one of the gill slits, and the worm soon wriggles its way out again. Often the Axolotl catches it again by the free end before the other is completely out of the gill slit, and begins another attempt to swallow it, and the process is sometimes repeated several times before actual deglutition is effected. The gill slits are evidently a considerable inconvenience to the Axolotl. The frog is much better off in having them closed, but man himself is not in a position entirely to despise the Axolotl: his lungs are derived from the same source originally, namely, modifications of the air-bladder of a remote aquatic ancestor, an inhabitant of the sea-coast, and they open into the throat just behind the tongue. In man there is a lid to close this opening and a contrivance to pull it under the tongue when swallowing takes place; but every one knows the agony entailed by getting a crumb the wrong way—an accident very much akin to that of the Axolotl, and similarly entailed by the use of a single passage for two different purposes—feeding and respiration. At such moments of suffering the naturalist is inclined to turn traitor and long that he had been produced in accordance with the hypothesis of special creation rather than evolved under the laws of natural selection. The existing arrangement must not be regarded as of inevitable necessity. The vertebrates are the only animals which breathe through their mouths. All other animals have separate passages for respiration and feeding. The common snail has a separate breathing passage completely apart from its mouth, the land crab breathes by openings at the bases of its legs, the scorpion by openings on its abdomen, and the insect by numerous apertures on the sides of its body. All these animals cannot, like man, choke themselves.

Only the pentadactyle vertebrata have adapted themselves completely for terrestrial respiration, but several fish have, by special modification of their gills, become able to remain out of water for almost indefinite periods. Most remarkable amongst these is Periophthalmus, one of the Gobiadæ inhabiting mud flats on the sea-shore in Australia, Ceylon. Fiji, and other eastern tropical regions. It hops along the mud with the greatest agility and so fast that it is most difficult to capture, and even refuses to take to the water when driven to it, skipping along its surface, and resting on projecting stones. It even climbs high up the mangrove trees and sits on the branches. All modes of air-breathing are derived by modification from aquatic breathing apparatus, except, perhaps, in the case of the air-breathing tracheata, the insects and their allies, in the ancestor of which, represented by Peripatus, the respiratory tubes or tracheæ were probably first formed as modifications of skin glands.

Littoral animals of most various kinds have taken from marine to terrestrial life no doubt by gradual adaptation, owing to exposure by the tides. Crustacea seem to have the greatest power of thus adapting themselves to aërial respiration by slight modification of their gill apparatus, so as to permit it to act as a lung. Nothing is more astonishing to the naturalist in tropical countries than to find large crabs amongst the vegetation far inland and high up mountains. But land crabs are not confined to the tropics: in Japan they may be met with walking across the high roads far inland, and 4000 feet above sea-level. One of the most remarkable instances is that of the cocoanut climbing crab, *Birgus latro*, which has developed, as Prof. Semper has shown, a regular pair of lungs out of the walls of its gill cavities. The animal was originally a hermit crab, but got too large for any shell, and thus developed hard plates on the surface of its body for protection instead. Close allies, but of much smaller size, swarm in some Pacific islands. They always bear shells, and carry them with them when they climb the trees and bushes. I have caught hold of the shell of one of them as it clung to the top of a branch, thinking that it was a land-mollusk, and have been astonished by receiving a sharp nip from a pair of claws.

The oldest-known air-breathing animals, so far as geological evidence goes, are scorpions and insects. An ally of the cockroach and two scorpions have lately been obtained from Silurian strata. The close affinities of the scorpions with the king crabs, and thus with the Trilobites, is a most interesting matter, which has lately been urged by Prof. Ray Lankester. He suggests that the lungs, by means of which the scorpions breathe air, are modifications of the gill plates of the king crab, which have become inverted for the purpose. The lung openings of Scorpio correspond with the gill plates of Limulus in position and number. Hence, possibly, the scorpions, and with them the rest of the Arachnida, are sprung from ancestral allies of the king crab and the Eurypterids, having passed from a littoral to a terrestrial existence.

It seems possible that birds were originally developed in connection with the sea-coast, and were fish-feeders. The tooth-bearing birds discovered by Prof. Marsh, such as Hesperornis and Ichthyornis, were marine aquatic

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birds. Hesperornis lived in a shallow tropical sea surrounding the present Rocky Mountains, then a group of islands. The modern penguins show some remarkable points of affinity to reptiles in the structure of their feet, and probably their embryonic development, when worked out, may throw much light on the past history of birds.

Some of the extinct Dinosauria which show remarkable affinities with birds were at least aquatic in habits.

The fauna of the coast has not only given origin to the terrestrial and freshwater faunas, it has throughout all time since life originated given additions to the pelagic fauna in return for having received from it its starting points. It has also received some of these pelagic forms back again to assume a fresh littoral existence. The terrestrial fauna has returned some forms to the shores, such as certain shore birds, seals, and the Polar bear; and some of these, such as the whales and a small oceanic insect, Halobates, have returned thence to pelagic life.

The deep-sea fauna has probably been formed almost entirely from the littoral, not in most remote antiquity, but only after food derived from the *débris* of the littoral and terrestrial faunas and floras became abundant in deep water. It was in the littoral region that all the primary branches of the zoological family tree were formed; all terrestrial and deep-sea forms have passed through a littoral phase, and amongst the representatives of the littoral fauna the recapitulative history, in the form of series of larval conditions, is most completely retained. It is for this reason that the researches carried on at marine laboratories on the coasts have yielded in the last few years such brilliant results.

BALLOON PHOTOGRAPHY[1]

RECENT experiments in photographic aërostation, carried out by M. Gaston Tissandier, with the assistance of M. Ducom, have been attended with very complete and satisfactory results. The photograph reproduced by heliogravure in Figs. 1 and 2 was taken at an altitude of 605 metres over Paris; others which were taken did not give such perfect results; nevertheless, some of them surpass in distinctness any yet taken by the same method. The ascent took place at Auteuil on June 19, M. Ducom attending specially to the photography, while M. Tissandier looked after the balloon. The photographic apparatus arranged in the car is shown in Fig. 3. The ascent took place at 1.40 p.m. with a south-west wind. Ten minutes after starting a first photograph was taken at 670 metres; soon afterwards another was taken at about the same height, in which a bridge, quay, public

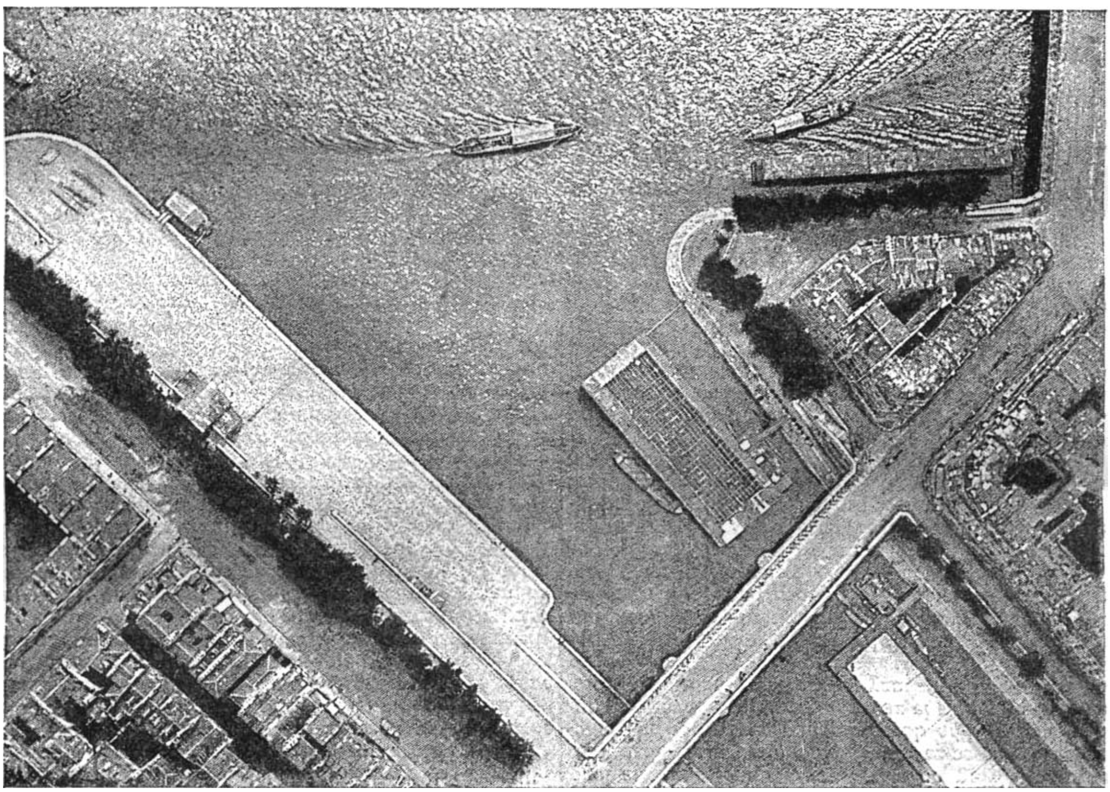

FIG. 1.—Reproduction by heliogravure of a plate taken at a height of 605 metres above Paris, showing the Seine, with two boats, Pont Louis-Philippe, gate of the Hôtel de Ville, &c.

office, fifteen cabs, a tramway, and the people in the streets were clearly reproduced. At 605 metres the photograph here reproduced was obtained, but unfortunately heliogravure does not produce an exact *fac-simile* in the fineness of the details. The smaller plan (No. 2) shows the exact topography of the place. When the photograph itself is examined through a magnifying glass many details are discovered, such as the coils of a rope mooring a boat to the shore, the passers-by, &c. On the photograph, too, the chimneys may be counted forming a number of small black spots on the roofs. A picture of great clearness, but rather greyish, was taken a few minutes later at an altitude of 800 metres above the prison of La Roquette; and another at the moment of leaving Paris at 820 metres. Beyond the city two more

[1] Abstract from *La Nature*.

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